



UTC Math Poster Competition 2024

Mathematics in Technology

Reinforcement

Reinforcement learning is a type of machine learning in which an agent interacts with an environment to try to maximize a total return. The agent learns by trying different actions and seeing the results. The agent learns to maximize rewards over time. For example, an agent might learn to play a game. AI and robotics to produce virtual environments. This learning technique is extremely useful for developing the best strategy and technique for completing a task.

Supervised learning

Supervised learning is a type of machine learning in which the algorithm is trained on a dataset of labeled examples. The algorithm learns to map input features to output labels. The algorithm is then used to predict the output label for new input features. Supervised learning is used in many applications, including spam filtering, image classification, and sentiment analysis.

Unsupervised

Unsupervised learning is a type of machine learning in which the algorithm is trained on a dataset of unlabeled examples. The algorithm learns to find patterns in the data. Unsupervised learning is used in many applications, including clustering, association rule mining, and anomaly detection.

Semi-Supervised

Semi-supervised learning is a type of machine learning in which the algorithm is trained on a dataset of partially labeled examples. The algorithm learns to find patterns in the data. Semi-supervised learning is used in many applications, including text classification, image classification, and sentiment analysis.

Machine Learning

Machine learning is a type of artificial intelligence that allows computers to learn from data without being explicitly programmed. Machine learning is used in many applications, including spam filtering, image classification, and sentiment analysis.

Target Market

Target market is a group of people who are most likely to buy a product or service. Target marketing is a strategy that focuses on identifying and reaching the target market.

World Population UN Future Forecast

The world population is projected to reach 9.7 billion by 2050. The UN Future Forecast shows that the world population will continue to grow, but at a slower rate than in the past.

Machine Learning Diagram

The diagram shows the Machine Learning process. It starts with a 'Data' input, which is processed by a 'Machine Learning' algorithm. The algorithm outputs a 'Result'. The result is then used to 'Update the Model', which is then used to 'Predict the Result'.

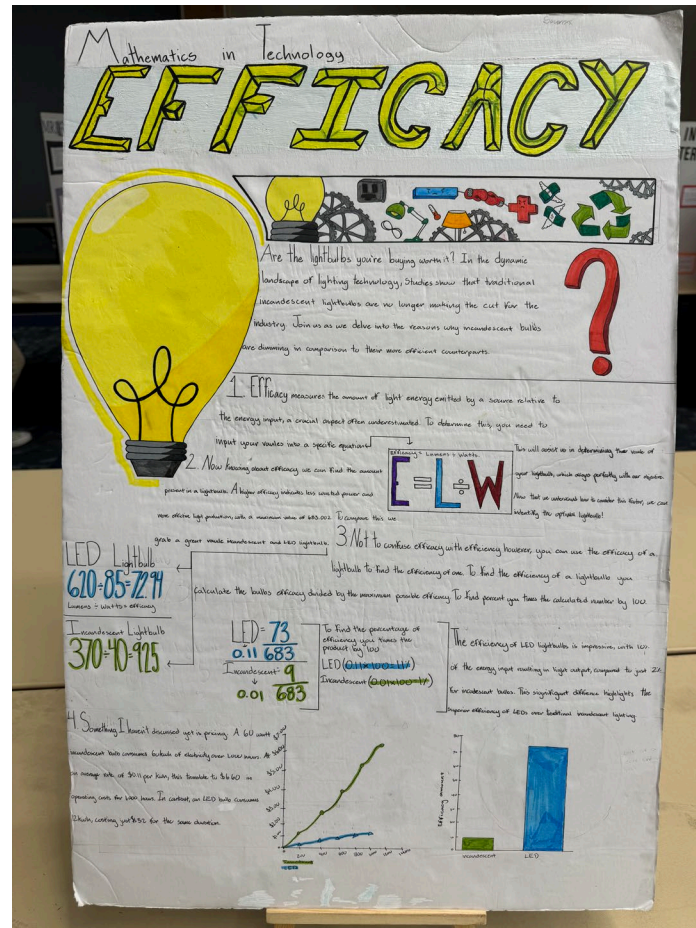
Target Market Diagram

The diagram shows the Target Market process. It starts with a 'Target Market' input, which is processed by a 'Target Marketing' algorithm. The algorithm outputs a 'Result'. The result is then used to 'Update the Model', which is then used to 'Predict the Result'.

QR Code

A QR code is located on the left side of the display board. It likely links to a website or a video related to the project.

Category I – 1st Place



CSAS
Chattanooga School of the Arts and Sciences

A Comparative Analysis of Plane and Avian Airfoils

Chattanooga Schools for the Arts and Sciences

Research Question:

How do the airfoils of current planes connect to the avian world?

Background and Introduction

Airfoils are defined as an optimized curved surface, designed to provide the best ratio of lift and drag in flight (Fig 1). Necessary to establish the wings, fins, and stabilizers within the majority of aircrafts, airfoils are essential to the aeronautical industry. Yet before humans reached the skies, the natural world existed as the only physical representation of flight, evolving through a perfect balance of adaptation and natural selection. In this analysis, we compare avian and manmade airfoils using the XFOIL software, as well as the combined efforts of our own research and the help of our instructors. Through the comparison of the control airfoils, which we found through a national database, and our developed bird foils, we found some interesting conclusions.

Methods

To completely understand the wings that we were designing, we used the XFOIL software to perform an in-depth analysis. XFOIL is a widely used computational tool for aerodynamic analysis, more specifically, for the assessment of the performance of airfoils. It allows for the variation of inputs such as airspeed, air density, angle of attack, turbulence model, number of iterations, coordinates, and geometry to be viewed. In the first step, XFOIL reads the coordinates of the airfoil, for example, NACA (National Advisory Committee for Aeronautics) values, which functions as a database for already existing airfoils and converts them to graphs. Afterward, specifying an angle of attack, the graph is then produced (as seen in the right figure), these graphs represent a physical interpretation of the shape of the airfoil. Using the NACA website, we gathered a variety of control airfoils, ranging from the Cessna 172 (Fig 2), to the P-51d (Fig 3), and then produced separate foils that represented our "natural" wings, or birds. The process that we used to develop these bird wings included finding similar airfoils from the database and changing certain values to match, for example, a stork foil. After gathering several control and bird airfoils and their respective graphs, we compared the results and made our conclusions.

Conclusions

1. All of the bird airfoils that we considered in this study appeared to have a similar counterpart within the NACA database. For example, the Albatross, S1210, was remarkably similar to NACA 0012, as described in the results.

2. The shape and different values of the bird airfoils, for example, the drag and lift coefficients all correlated to the way in which the bird flies. For instance, the stork tends to glide, which means the drag coefficients are reduced and it has a long stretched out section of the airfoils cambers.

3. Although in most cases the airplane foils were remarkably similar to the avian foils, the birds tended to have a much more drawn out trailing edge, leading to generally higher pitching moment.

Results

As evident from the XFOIL results, the more organic airfoils of birds create more organic distributions in the graphs. This is due to a higher camber of the airfoils. Specifically, for the AS6091 airfoil – representing the stork – thin upper and lower cambers mean that drag is reduced and lift is maintained. Furthermore, the airfoils for the birds and planes tend to correlate very well from a geometrical perspective. For example, the albatross is characterized by S1210 and has a very similar leading edge to the NACA 0012 airfoil, notably used in the Boeing 707. One very noticeable difference between the natural airfoils is the far larger pitching moment, which is increased by the thin trailing edge of natural airfoils. This can be attributed to the thin light feathers, which allow for lift, as well as maneuverability, something that is not allowed in traditional planes. The P-51d, as characterized by NACA 0317, has a pitching moment of -0.022 at an attack angle of 10 degrees (Fig 4), -0.011 at 5 degrees, and 0 at 0 degrees. For the airfoil S1223, characterizing the similar seagull, a pitching moment of -0.37 at 10 degrees (Fig 5), -0.36 at 5 degrees, and -0.36 at 0 degrees.

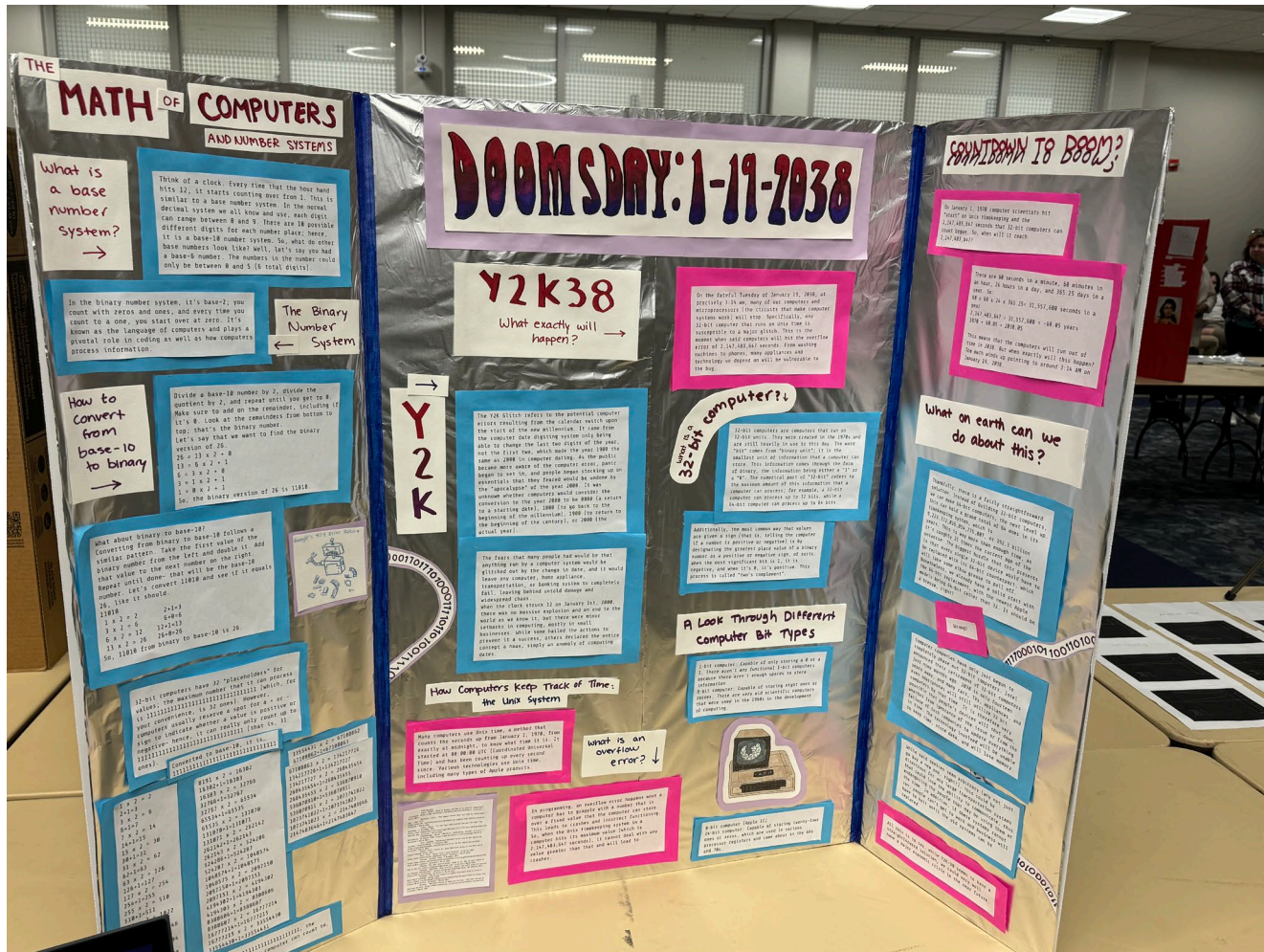
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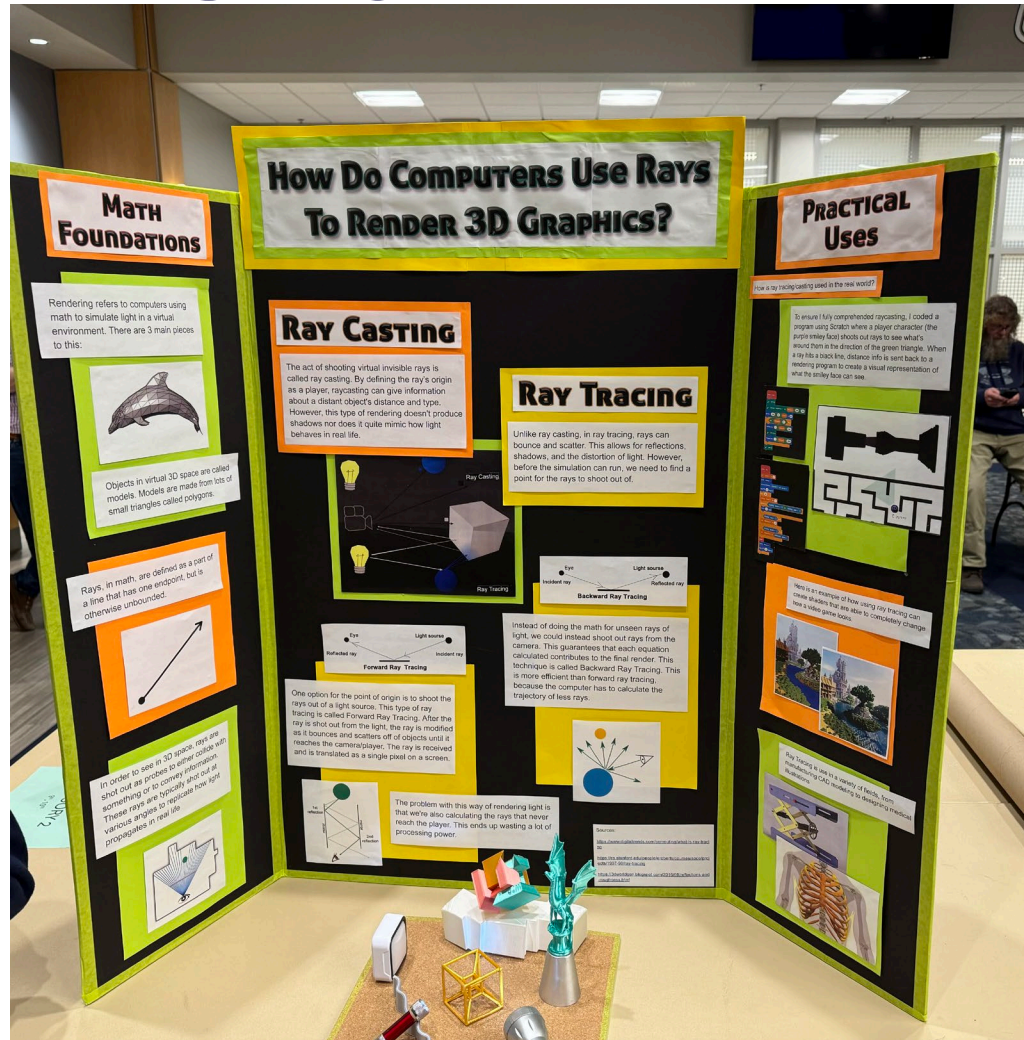
Acknowledgements

For this project, we would like to acknowledge Dr. Ramesh Ranjan. He provided guidance to us in the usage of XFOIL, and a general understanding of the content of this project. Our teacher, Mrs. Chavala, also helped us with our thoughts and created a supportive working towards our goal.


Category II - 2nd Place



Category II – 1st Place




Category III – 3rd Place

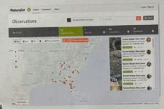
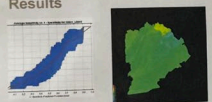
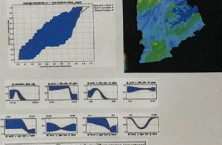
 **Modeling Species Distribution Using MaxEnt Algorithm with *Ophisaurus ventralis***
Chattanooga [REDACTED] and Sciences

Research Question
Can machine learning software be used to create accurate species distribution models?

Background or Introduction
MaxEnt is an open source software that uses presence only data and a set of environmental variables in grid cells that are set by the user. In this project presence locations from from East coast states were used as inputs as well as bioclimatic variables to create a species distribution model for the genus *Ophisaurus*, common name glass lizards.

 Photos of glass lizards, depicted on the left. Species presence points found on iNaturalist pictured above.

Methods
Presence only (PO) data was gathered from iNaturalist. Citings were captured and imported into Esi where Arcmap was used to convert the data to 8-32 bit rasters with a cell size of 30 meters. The environmental variables were retrieved from wordclim.org and were converted to the same format using the same application. The PO data was exported as a .CSV file and imported into the "samples" section of the MaxEnt program. The processed environmental variables were exported as ASC files and imported into the "Environmental Layers" section of the Program. Variables BIO 1,3,5,8,10,12,15 were chosen based off of a similar study of european glass lizards. Most standard settings of the program were used. For the second run the regularization multiplier was varied to try for a better AUC.

Results




Variable	Mean	Standard Deviation	Minimum	Maximum
BIO1	10.5	1.2	8.5	12.5
BIO3	15.2	1.5	13.2	17.2
BIO5	20.8	1.8	18.8	22.8
BIO8	25.4	2.1	23.4	27.4
BIO10	30.1	2.4	28.1	32.1
BIO12	35.7	2.7	33.7	37.7
BIO15	40.3	3.0	38.3	42.3

Variable	Mean	Standard Deviation	Minimum	Maximum
BIO1	10.5	1.2	8.5	12.5
BIO3	15.2	1.5	13.2	17.2
BIO5	20.8	1.8	18.8	22.8
BIO8	25.4	2.1	23.4	27.4
BIO10	30.1	2.4	28.1	32.1
BIO12	35.7	2.7	33.7	37.7
BIO15	40.3	3.0	38.3	42.3

The graphs on the right are results from run 1. It had an AUC score of 0.438 which is not acceptable for field work. There was an uneven distribution of the use of the environmental variables. The map reflects the limited variation in the results. The graphs on the right are results of runs 3 and 4. The AUC increased to 0.519 and then increased again to 0.705 which is acceptable for field testing.

Conclusions
There is a possibility that there are glass lizards in the tristate area surrounding Chattanooga, Tennessee. The areas of greatest interest are Morgan county, TN, Grundy county, TN, Jackson county, AL, and Pickens county, GA. Field testing should be carried out in these locations.

Acknowledgements
Thank you to Kelly Davis for providing a computer and time for the project. Big thanks and a shoutout to my friend, [REDACTED], for introducing me to this process and answering my many many questions. I couldn't do it without you and your beefy computer.

References
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Category III - 2nd Place

What Even is pH?
pH is a measure of acidity and basicity. The scale goes from 0-14, with 0 being the most acidic and 14 being the most basic, or alkaline.

THE pH SCALE

Why It Matters
While it might seem silly or even pointless to learn about pH and how we use technology to find it, pH has applications in your daily life. A balanced pH in our body keeps us alive!

The pH of different fluids in the body:
Blood: 7.35-7.45
Saliva: 6.5-7.5
Upper Part of the Stomach: 4-5
Lower Part of the Stomach: 1-2
Intestine: 7-8.5

If these pH values in the body become unbalanced, the results could include coma and even death.

A pH meter is an electronic device that's used to measure the pH of liquids. The value of pH is determined by the hydrogen ions $[H^+]$ in a solution. The meter's electrodes are used to sense the pH of a solution. The meter uses something called the **Nernst equation** that utilizes logarithms.

Graph of the pH of Potassium (red). Do you see any trends?

pH Meters
What are they, what do they do, and why do we need them?

Statements of Purpose: This topic was chosen from a place of love for science, technology, and math, as the pH is a widely used concept. I hope that the audience gains confidence, understanding of why pH matters, the math behind it, and how we use technology to find it.

Created By: Addison Howard

Start Here

$E = E^\circ - \frac{0.0592}{n} \log Q$

$[H^+] = 3.4 \times 10^{-11}$

$pH = 10.5$

Example Problem:
What is the pH in a solution in which $Mg^{2+} = 1.20 \text{ M}$ and pressure of $H_2 = 1.00 \text{ atm}$, if the E° of the cell is 2.039 V (over)?

$Mg(s) + 2 H^+ \rightleftharpoons Mg^{2+}(aq) + H_2(g) \quad E^\circ_{cell} = 2.363$

Steps to Solve:
1. Plug in known values into the simplified Nernst equation.
2. Solve for $[H^+]$ - Plug into equation.
3. Solve for $[H^+]$ - Plug into equation.
4. Solve for $[H^+]$ - Plug into equation.
5. Take the inverse log of both sides (antilog).
6. Use the negative log of $[H^+]$.

Nernst Equation
 $E = E^\circ - \frac{0.0592}{n} \log Q$

We'll use a simplified version of this equation, assuming an ideal temperature of 25°C (298 K) and an ideal behavior electrode.

$E = E^\circ - \frac{0.0592}{n} \log Q$

The Relationship Between Logarithms and Exponentials in pH
The relationship between an exponential and logarithm is generally expressed with the following:
 $b^x = a \Rightarrow \log_b a = x$

Example Problem:
 $10^x = 243 \Rightarrow \log(243) = x$

When a problem gives either pH or $[H^+]$, we utilize this relationship to solve for the entity we aren't given.

Questions You May Have
1. Why do we use logarithms to solve for pH?
We use logarithms because pH is about the concentration of hydrogen ions. This value changes a lot, so we use a logarithmic scale to better represent and understand it.
2. Why is the logarithm negative?
The logarithm is negative because the $[H^+]$ concentration is always a fraction that is less than 1.

A Brief Summary
The pH of a solution is the representation of hydrogen ions $[H^+]$ in the solution. To find pH, we use a piece of technology called a pH meter. The meter uses electrodes to find the difference in $[H^+]$ ion concentration through its internal reference solution and an outer electrode to measure the external solution. This exact number is found using the Nernst equation, which utilizes logarithms. The relationship between pH and $[H^+]$ ions can be modeled by an expression showing the relationship between logarithms and exponentials, where the pH is logarithmic and the $[H^+]$ ion concentration is exponential. Understanding pH and how it's calculated is important as pH affects us daily from the pH values in our body to the pH values of things around us such as in our environment and cleaning products.

Example Problem:
If $[H^+] = 3.4 \times 10^{-11} \text{ M}$, what is the pH?
We'll use the relationship between pH and $[H^+]$ concentration and then multiply it by 10 to find the pH.
 $pH = -\log(3.4 \times 10^{-11}) = 10.5$

Example Problem:
If we're given the pH, we calculate the pH using a logarithmic operation.
If $pH = 10.5$, what is $[H^+]$?
We'll use the relationship between pH and $[H^+]$ concentration and then multiply it by 10 to find the $[H^+]$.
 $[H^+] = 10^{-10.5} = 3.4 \times 10^{-11} \text{ M}$

COFFEE
(from the back table!)

Will My Hair Dryer BLOW SLOWER IN EUROPE?

What is Alternating Current (AC)?

Definitions:

- Current: a flow of electrons
- Voltage: electromotive force, the "pressure" force with which current flows

The electricity that flows from an outlet is produced by a generator in a power plant. As the metal rotator in the generator rotates through a surrounding magnetic field, this induces an electric current. The electron (carrying the current) are "pushed" either forward or "backward" based on the attraction of the magnetic field relative to the rotational angle of the armature, creating current that oscillates between positive and negative flow.

GENERATION

Armature Rotating to Induce Potential
Magnetic Field
ARMATURE

No voltage induced when armature rotated parallel with magnetic field

Increasing voltage as armature approaches perpendicular points

Peak Voltage

No voltage induced when armature is perpendicular to magnetic field

As armature continues to rotate, it reverses direction and polarity

EDUCATION: $e = E_m \sin \omega t$

The maximum voltage or current is related to the peak value of the sine wave. The effective value is the average value in the periodic circuit.

$E_{eff} = \frac{E_m}{\sqrt{2}}$

EUROPE

Power Plant

AC Output: 50 Hz, 230V

must use an adapter/transformer to switch the 230 v European current to the 120 v required by the American hair dryer. This will NOT however, change the current's frequency

HAIR DRYER
High Speed Ionic Hair Dryer model AGC-18, 6500 rpm
• AC electric motor
• Intended for use in United States (60 Hz, 120v)

USA

Power Plant

AC Output: 60 Hz, 120V

Hair dryer made for 120v 60Hz will blow at intended 180,000 rpm

50 Hz vs 60 Hz Electrical Current

Definition:

- Cycle/period: the time required for an alternating current wave to repeat (a full cycle of positive and negative flow)
- Frequency: the rate at which the current repeats/oscillates
- Hertz: a measure of frequency
- 1 Hz = 1 cycle/second

A different countries' power plant generates are set to spin at different speeds and therefore produce currents of different frequencies.

EUROPE

generators produce current at 50 Hz, delivered to outlets at 230 volts

voltage at given time interval

$$e = 325 \sin 100\pi t$$

max voltage angular velocity of generator

$\omega = 2\pi f = 2\pi(50) = 100\pi$ radians/sec

This is the RMS value (see below)

Europe: 230 V, 50 Hz

US: 120 V, 60 Hz

UNITED STATES

generators produce current at 60 Hz, delivered to outlets at 120 volts

voltage at given time interval

$$e = 170 \sin 120\pi t$$

max voltage angular velocity of generator

$\omega = 2\pi f = 2\pi(60) = 120\pi$ radians/sec

Usage of the Current

The frequency of alternating current is important because it determines how fast the current changes direction. In a household AC system, the current changes direction 50 or 60 times per second. This means that the voltage across a load is always changing. The average value of the current over one complete cycle is zero. However, since the current is always changing, we can define an effective value for the current. This is called the root mean square (RMS) value. The RMS value of a sinusoidal current is equal to the peak value divided by the square root of two.

RMS Value in AC Voltage

The RMS value of a sinusoidal voltage is equal to the peak value divided by the square root of two. For example, if the peak voltage is 170V, the RMS value is 120V.

Example Peak Value

European Peak Value: 240V

US Peak Value: 170V

US RMS Value: 120V

European RMS Value: 170V

Congratulations!



Bridges Beyond the Classroom

C THE UNIVERSITY OF TENNESSEE
CHATTANOOGA